PSC Overview Series . . . Electric Power Plants

This Overview addresses some of the issues relevant to electric power supply technologies, such as conventional coal-fired and natural gas-fired power plants, as well as new or developing technologies and cogeneration.

How Power Plants Work

Power plants use rotating electric generators to convert mechanical energy into electricity. Rotary engines, called turbines, are used to harness mechanical energy from flowing water, steam, fossil fuel combustion, wind, or nuclear reaction.

Units of Measure

Power plants are typically rated in megawatts (MW). A megawatt is a measure of power, equal to 1,000 kilowatts (kW) or one million watts. Most home air conditioners need 2 kW when they are running. Ten 100-watt light bulbs need 1 kW. A power plant rated at 1 MW will supply enough energy to operate 500 home air conditioners or ten thousand 100-watt bulbs simultaneously.

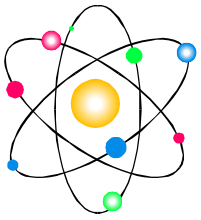
Options for Producing Electricity

Coal-fired plant

Coal-fired power plants burn coal to heat water to produce high-pressure steam. This steam turns a steam turbine that drives an electric generator. Coal plants have high construction costs, but relatively low fuel costs. Because of the low fuel costs, many of these plants are run almost constantly as "baseload" plants. Burning coal releases sulfur dioxide (SO_2), nitrogen oxides (NOx), carbon dioxide (CO_2), and small particles of ash (which include some toxic metals). Control technologies were installed to control the level of pollutant emissions into the air.

Nuclear plant

In nuclear plants, the heat from the splitting of uranium atoms in a controlled reaction heats water to produce steam. The steam turns a steam turbine that drives an electric generator. Even more than coal plants, nuclear plants are designed to be run as baseload generation. The main environmental concerns are not about air emissions but about safety and the storage and disposal of spent nuclear fuel.



Combustion turbine

Combustion turbine (CT) power plants typically burn natural gas. The resulting hot gases rotate a turbine that drives an electric generator. CTs operate in a way similar to jet engines. CTs have lower construction costs than coal or combined-cycle plants, but higher fuel costs. Because of their high fuel costs, these

plants are usually run as "peaking plants" in times of peak demand or other special needs. Burning natural gas releases NOx and CO_2 into the air.

Combined cycle plant

Combined-cycle (CC) power plants also typically burn natural gas, and a portion of their power output is from the part of the plant that is a CT. However, a CC plant is more efficient than the CT described above, because the hot "waste" gases of the CT are used to produce steam that drives a second electric generator. Burning natural gas releases NOx and CO_2 into the air. CCs typically have construction costs and operating costs between those of coal plants and CTs. They are run as "intermediate" plants, operating more hours than peaking plants but fewer than baseload plants.

Diesel generator

Diesel generators are much smaller in size, producing usually from 1,000 to 3,000 kW. They use diesel engines fueled by fuel oil and natural gas. They are typically installed by municipal utilities as stand-by.

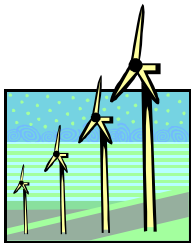
Renewable resources

Renewable resources generate electricity without using conventional fuels such as coal, natural gas, oil, and uranium. Renewable resources can be utility-owned or customer-owned. They can be small and dispersed throughout the electric system or large and centralized. They can burn renewable fuels or avoid combustion altogether. The following are five types of renewable resources:

Hydroelectric power

In hydroelectric plants, falling water turns a turbine that drives a generator to produce electricity. Sizes range from large, utility-owned dams on major rivers to small "mom and pop" dams on small streams. Hydroelectric power plants have high construction costs, but are long-lived and have very low energy costs.

Wind power



Wind turbines are mounted on tall poles. The wind turns blades that drive a generator. Wind plant sizes range from large-scale "wind farms" to small-scale wind machines. Wind power has high construction costs, but very low environmental costs and very low energy costs. In areas where wind speeds are high and consistent, wind power is now cost-competitive with traditional power plants.

Solar—photovoltaic power

Solar cells convert sunlight directly into electricity as in solar-powered calculators. A solar plant consists of an array of panels. Solar power has very high initial costs, but very low energy costs. Solar power is most cost-effective in areas that are remote from existing power lines. The price of solar energy is dropping rapidly with new technology breakthroughs.

Biomass plant

Biomass power plants burn plant materials (wood, wood residue, farm energy crops) in boilers. Fuel is burned alone, mixed with fossil fuels, or gasified. Unlike fossil fuels, biomass can be part of a closed carbon cycle. It can be planted and grown, capturing CO_2 equal to the amount of CO_2 emitted during burning. The steam produced from burning biomass can also be used to turn a second generator as it does in a natural gas-fired CC plant.

Solid waste

Waste-to-energy power plants burn municipal or industrial waste either directly or after it is processed into refuse-derived-fuel which removes metals and other toxic wastes and noncombustible materials. Tire-derived-fuel is another energy source. Collecting and burning methane gas from landfills (landfill gas fuel) is also possible.

Power Plants in Wisconsin

Existing generating capacity in Wisconsin by fuel type (Figure 1) and plant type (Figure 2) are shown on the following graphs.

Figure 1 Wisconsin generation capacity by fuel type

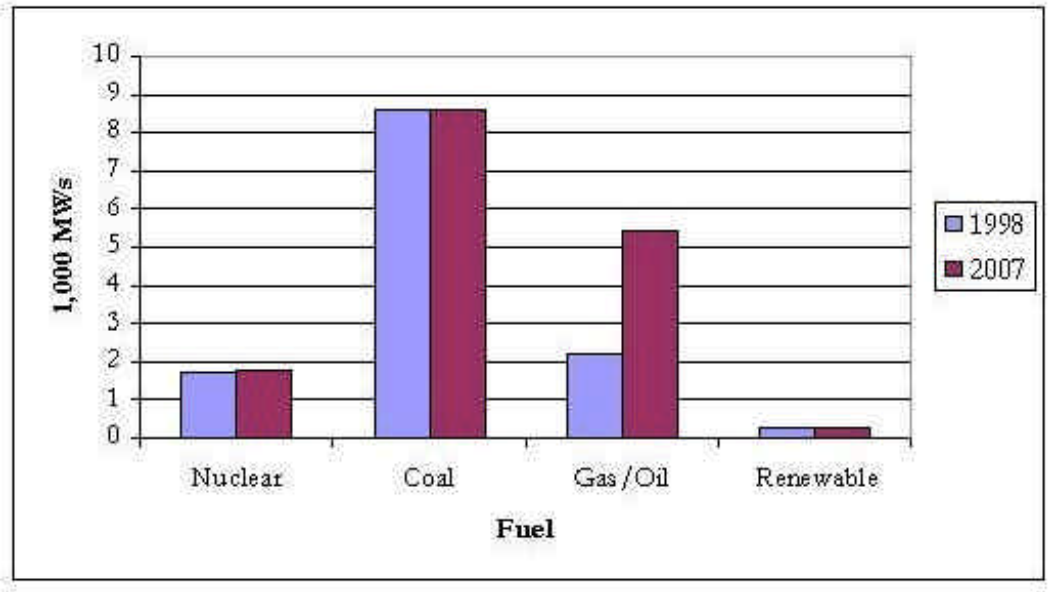
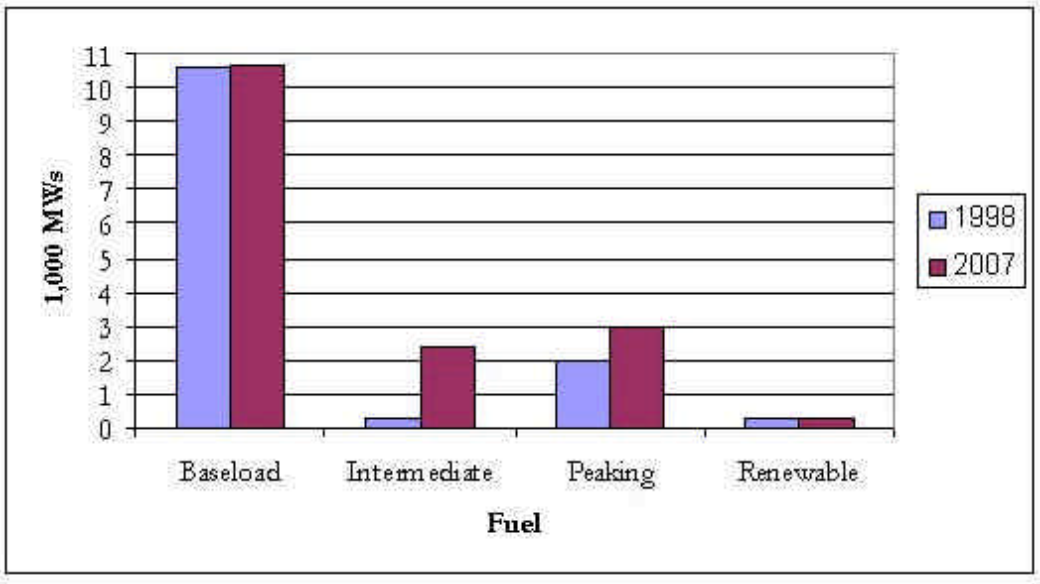


Figure 2 Wisconsin generation capacity by plant type



New Technologies

Methods of producing electricity evolve as new technologies become available. There are new ways of burning fuel, such as fluidized bed boilers, and new fuels, such as gasified coal. New processes, such as fuel cells, convert gas fuel directly to electricity. Some advances are in the form of improvements, such as larger and more efficient combustion turbines. Others are in the form of smaller, more widely distributed local generation.

Microturbines are small-scale gas turbines. They hold promise of being safe, reliable, and low-cost generators of electricity at the point of use. They can use a variety of fuels, such as natural gas, diesel, unleaded gasoline, or alcohol. They can meet the energy needs of a restaurant, hospital, school, or a small business. Their mass production is expected to bring their costs to or lower than $500 per kW. Battery storage is used in conjunction with smaller generators to save the power produced until it can be used. Fuel cells are similar to batteries except that they produce their own energy chemically.

Although the contribution of newer technologies is relatively small, as the technical and economic feasibility of these methods improve, their contribution will grow.

Need for new Power Plants

Although the rate of growth in electricity use has varied over time, there has been a general trend of growth in the demand for electricity throughout the state. New customers, the increase in average use per customer, and the overall economic growth in the state have resulted in increasing demands on Wisconsin's existing power plants. Growth projections for the immediate future indicate approximately 200 to 300 MW of new power plants will need to be built each year.

Power plants eventually reach a condition where they need to be either refurbished or retired. If they are retired, new plants must be built to replace them.

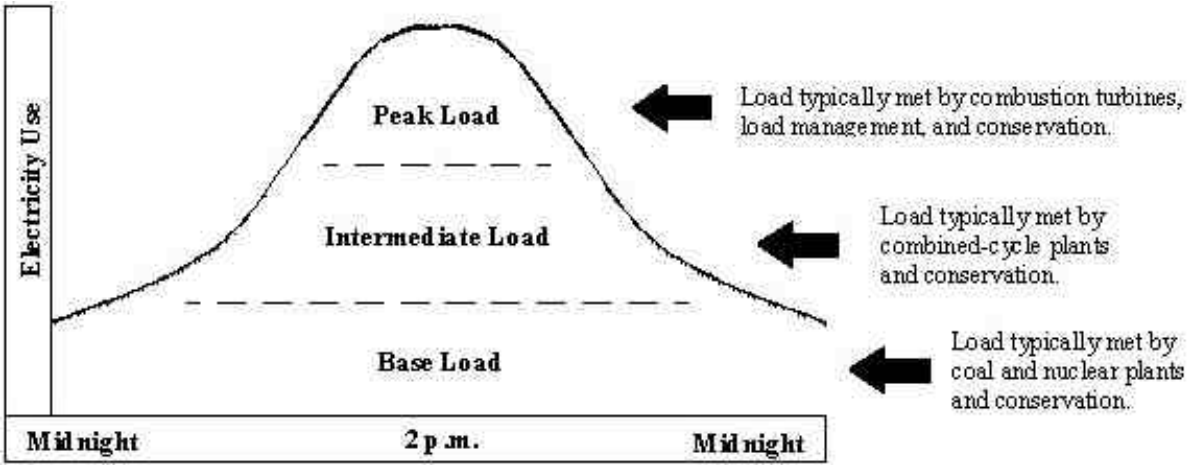
Increasing the efficiency of energy use, or shifting the time of energy use will help delay or reduce the need for new power plants. See the PSC Overview entitled "Electric Energy Efficiency." It is also possible to modify older, existing plants to extend their lives or increase their electrical output.

A specific life-extension issue involves the continued operation of the state's two nuclear power plants. The 40-year original term of their license (issued by the Nuclear Regulatory Commission) will expire in 2010 for Point Beach Nuclear Power Plant (PBNPP) Unit 1 and in 2013 for PBNPP Unit 2 and the Kewaunee Nuclear Power Plant. See the PSC Overview entitled "Nuclear Power Plant Decommissioning and Radioactive Waste Disposal."

Electricity use Patterns

The amount of electricity demanded by customers changes daily and seasonally. People turn their air conditioners on and off. A manufacturing plant starts and stops its assembly line. The curve in Figure 3 shows the total amount of electricity that a utility's customers demand at each point in a day. Utilities build generating capacity, or power plants, to meet this demand. The area under the line shows the total amount of electric energy used by customers in a day. Power plants produce this energy.

Figure 3 Load curve



Demand is the total amount of electricity customers demand at each point in time, measured in watts (W), kW, or MW. Energy is the total amount of electricity customers use over time, measured in watt-hours (Wh), kilowatt-hours (kWh), or megawatt-hours (MWh).

Utilities use a mix of resources to meet their customers' demand. Each resource has its own characteristics that are useful for meeting some types of load (demand) but not others.

Load management and conservation contribute to reducing energy demands during peak load periods. Conservation can also contribute to reducing base load and intermediate demand for energy.

In general, because peaking plants run during times of high demand, new plants can be relatively costly to operate, but they usually require a smaller investment (lower cost) to build. Simple-cycle gas-fired combustion turbines are often built as "peakers." In contrast, plants built to meet base load often require a substantial financial investment (high cost) to build, but they are relatively inexpensive to operate over long

periods of time. Coal plants and nuclear plants currently make up most of Wisconsin's base load capacity. Plants built to meet intermediate load demands generally operate more efficiently (at less cost) than peaking plants but may be more expensive to build.

The Role of the Public Service Commission and the Department of Natural Resources

The Public Service Commission (PSC or Commission)[1] is the state agency that has primary authority over power plant construction. It determines whether or not a project can be built and where it should be built if approved. Construction of any power plant greater than 100 MW requires a Certificate of Public Convenience and Necessity from the PSC, and a utility-proposed project 100 MW or less requires a Certificate of Authority. The Department of Natural Resources issues permits for power plant projects related to air emissions, water discharge, and waste disposal.

Utilities or independent power producers (IPPs) may build power plants. All proposed projects above 100 MW undergo a siting review in which environmental factors are considered to determine where the plant should be located. Projects proposed by utilities are also reviewed to ensure that they are needed and that the new energy is being provided by the least-cost alternative. Need and economic aspects are not considered by the PSC when reviewing power plants proposed by IPPs (merchant plants).

Major Issues in Power Plant Construction Cases

In construction cases, the PSC considers: air and water quality; the impact of associated electric lines and/or gas pipelines; safety; noise; the disposal of waste products such as ash; and the effect that building a new power plant will have on electric rates, wildlife habitat, land use, property values, aesthetics, and the quality of life in the area. Effects on historical and archeological resources are also assessed.

Air quality is one of the most widely discussed issues associated with the construction of new power plants. Public awareness and concern over air quality problems, such as global warming, acid rain, toxins such as mercury, and ozone pollution and depletion has grown over recent years. Laws and regulations have been developed to address these concerns and to limit emissions from new and existing sources of pollutants.

Factors That Affect Plant Location

Many factors are considered in power plant location, including: the type and size of the plant, access to fuel and water resources, location of electric transmission lines and substations, land availability, existing air and water quality at the site, the total cost of construction at the site, availability of nearby steam users if appropriate, and surrounding land use. These factors and public input are carefully reviewed and used as the basis for choosing sites. For more information, see the PSC Overview on Power Plant Siting.

The Public's Role

Public involvement is important to the Commission since its decisions are based on public hearing records. To prepare the public to take part in these hearings, the PSC holds public meetings and provides written

[1] "The Commission" means the three Commissioners acting as a decision-making body. "PSC" means the agency as a whole.

information, such as the PSC Overviews. Meetings and hearings for construction cases are held in the project area. In addition, comments from the public are welcome throughout the PSC project review process.

New Power Plants in Wisconsin

The Wisconsin utilities have planned six peaking plants and nine intermediate plants through 2007. They have also planned a small amount of wind generation. A few peaking units are planned for retirement. The utilities envision no need for new baseload generation through 2007. Beginning in 1998, IPPs can build plants in Wisconsin either in fulfillment of a utility's need or on speculation. The total amount of generation that may be provided by IPPs through 2007 is estimated to be more than 2,000 MW.

The Strategic Energy Assessment

The Strategic Energy Assessment (SEA) is reported biennially by the PSC. It identifies new power plants and transmission projects that are planned to begin construction during the following three years. Some of the energy issues addressed in the SEA include:

- Adequacy and reliability of the state's current and future electric energy supply.
- Identification of new utility generation and transmission.
- Adequacy and reliability of purchased generation capacity and energy.
- Adequacy of transmission transfer capability.
- Projected demand for electric energy.
- Identification of activities to discourage inefficient and excessive power use.
- Identification of existing and planned facilities that produce energy using renewable resources.
- Economic development, public health and safety, environmental protection, and diversification of supply.
- Adequacy of the regional bulk-power market.
- Contribution of competition to low-cost electricity.

The SEA report is issued in July of even-numbered years. Copies can be obtained by contacting the PSC.

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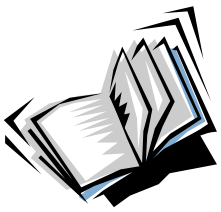
PSC Overview series

The Public Service Commission has prepared other Overviews for important electric issues. These are:



- Air Quality Issues for Electric Power Generation
- Electric Energy Efficiency
- Electric Transmission Lines
- EMF -Electric and Magnetic Fields
- Environmental Impacts of Electric Transmission Lines
- Merchant Plants and Other Non-Utility Generation
- Nuclear Power Plant Decommissioning and Radioactive Waste Disposal
- Common Power Plant Siting Criteria
- Renewable Energy Resources
- Right-of-Way and Easements in Electric Facility Construction
- Underground Electric Transmission Lines

To obtain any of these Overviews, contact the Public Service Commission, by phone (608) 261-8524 or e-mail *pscrecs@psc.state.wi.us*, or check our home page at : http://www.psc.state.wi.us.

The Public Service Commission does not discriminate on the basis of disability in the provision of programs, services, or employment. If you are speech, hearing, or visually impaired and need assistance, call (608) 266-5481 or TTY (608) 267-1479. We will try to find another way to get the information to you in a usable form.

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